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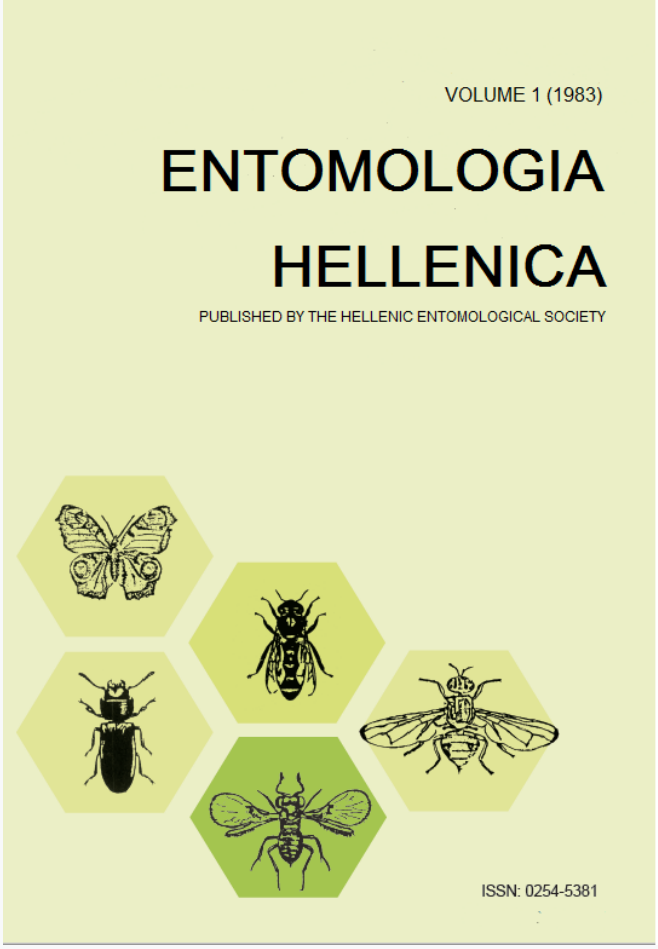

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D.P Lykouressis

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Key for the Identification of the Instars of the English Grain Aphid, *Sitobion avenae* (F.) (Hemiptera: Aphididae)[1,2]

D.P. LYKOURESSIS[3]

Department of Agriculture and Horticulture
University of Reading

ABSTRACT

A key is given for the identification of the instars of the English grain aphid, *Sitobion avenae* (F.), based upon morphological characters of the antennae, cauda and sub-anal plate.

Introduction

Aphid populations are characterized by facultative polymorphism and overlapping generations (Hughes 1972), features which complicate the study of their population dynamics. Hughes (1963) developed a demographic method which enabled him to estimate quantitatively the effects of mortality agents in populations of *Brevicoryne brassicae* (L.) under field conditions, overcoming difficulties caused by the overlapping of generations.

This method has been widely used by the International Biological Programme to study the population dynamics of *Myzus persicae* (Sulz.) (Foster and van Emden 1976), in other aphid population dynamics studies (Foster 1972, Dransfield 1975, Dickson 1979) and in a study on the effects of parasites on the population dynamics of *S. avenae* (Lykouressis 1982). It was for this latter study that the present Key for the identification of the instars of *S. avenae* was developed, since Hughes' method requires the instars of the aphid species to be distinguished. Also, Dodd (1976) constructed a Key for the identification of the instars of *B. brassicae* necessary to study host-plant resistance using the potential increase rate (PIR).

Otake (1958) developed a Key for immature stages of *S. avenae* but this did not enable him to distinguish the different instars with certainty. He stated that the only difference between the first and second instars was the shape of the tip of the abdomen and he did not find any morphological differences between the third and fourth apterous instars. He concluded that the third and fourth apterous instars could be distinguished with some degree of certainty from the total length of the third and fourth antennal segments. Also he did not ascertain at which instar wing pads appear.

Materials and Methods

Aphids originated from stock cultures maintained in a glasshouse. Fourth instar aphids were put in leaf clip-on cages on the first and second leaf of potted wheat seedlings (cr. Maris Kinsman) under glasshouse conditions at approximately 20° C, 60-80% relative humidity and a 16:8 hours light-dark cycle. Aphids were allowed to reproduce. New-born aphids were reared individually in clip-on cages and inspected at 6 hour intervals (from 8.00-20.00 h) to

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[2] This paper is part of the author's Ph.d. thesis: "Studies under controlled conditions on the effects of parasites on the population dynamics of *Sitobion avenae* (F.)", submitted to the University of Reading.
[3] Present address: Department of Agricultural Zoology and Entomology, College of Agricultural Sciences of Athens, Votanikos, Athens, Greece.

record the time of their moult to the next instar.

First instar aphids were collected very soon after their birth and well before their first moult, whilst for each of the successive instars aphids were collected after the moult and at various stages towards the end of the instar but before the next ecdysis. This was in an attempt to obtain and examine different size aphids within each instar.

The aphids collected at each instar were put in fluid storage, macerated, cleared and mounted on microscope slides,according to Eastop and van Emden (1972).

Most of the features used for the development of the Key have been listed by Eastop and van Emden (1972). For each instar the following characters were examined and their frequency recorded:

Number of antennal segments
Number of setae on cauda
Number of setae on sub-anal plate
Existence of setae on the third antennal segment
Existence of wing pads

Additional measurements were made upon several external features of the instars such us:

Length of the third, fourth and fifth antennal segments

Total length of the third, fourth and fifth antennal segments

Length ratio of the third to the fourth antennal segment

Length of the hind tibiae
Length of the siphunculi

For the differences found among the various immature stages of *S. avenae*, t-tests were conducted, where it was necessary, allowing for inequality of variances. The reliability of these differences, listed below, was checked in a population of *S. avenae* obtained from another source (Imperial College). Known instar aphids were obtained by the procedure described above.

Results and Discussion

Tables 1, 2 and 3 show differences found in the number and measurements of certain external morphological features of the various instars of *S. avenae*. Figure 1 also shows the differences found in the antennae and cauda of different instars of *S. avenae*.

First and second instar

Both instars have five-segmented antenae. However, there are no setae on antennal segment III in the first instar. The third segment in the second instar is more elongated and significantly longer than in the first instar and is divided into two non-articulate sub-segments under the cuticle, which are most clearly visible in old second instar aphids. There is no overlap in the range of lengths of the third and fourth antennal segments, hind tibiae and siphunculi in the two first instars. A highly significant difference was also found in the ratio of antennal segment III to antennal segment IV ($P < 0.001$). The most convenient feature for quick separation of the first and second instars is the length of antennal segment III.

There is also a difference between first and second instars in the number of setae on the cauda and on the sub-anal plate. However, this is not a practical method of distinguishing between the two instars because it requires slide mounting.

Third and fourth instar

The antennae in both instars have six segments,

TABLE 1. Means and standard deviation in morphological measurements of the instars of *Sitobion avenae* at approx. 20° C.

Instar	n	No. of antennal segments	No. of setae on cauda	No. of setae on sub-anal plate
I	60	5	2±0	5±0
II	82	5	6.76±0.55	7.97±0.54
IIIa	89	6	8.04±1.07	10.26±1.76
IIIw	71	6	8.21±1.26	10.88±1.22
IVa	51	6	9.00±1.57	14.00±1.70
IVw	64	6	8.96±1.56	14.28±1.55

n = number of observations.
IIIa, IVa = Third and fourth apterous instar.
IIIw, IVw = Third and fourth alate instar.

TABLE 2. Range, mean and standard error of the length of antennal segments in each instar of *Sitobion avenae* in μm at 20° C.

		Antennal segment							
						Fifth		Sixth	
		First	Second	Third	Fourth	Basal part	Processus terminalis	Basal part	Processus terminalis
I	Range	56.0-56.0	56.0-56.0	112.0-140.0	84.0-112.0	56.0-70.0	280.0-364.0		
	Mean±S.E	56.0±0.00	56.0±0.00	126.6±1.0	94.7±1.1	66,7±0.6	312.4±3.1		
	(n=86)								
II	Range	56.0-84.0	56.0-70.0	196.0-280.0	126.0-168.0	70.0-84.0	392.0-476.0		
	Mean±S.E	70.2±0.7	63.4±0.9	249.5±2.6	146,5±1.5	80.9±0.7	438.2±3.4		
	(n=60)								
IIIa	Range	84.0–98.0	70.0–84.0	196.0–252.0	182.0–252.0	168.0–252.0		98.0–112.0	462.0–658.0
	Mean±S.E	85.3±0.5	83.1±0.4	214.7±2.0	214.0±2.6	211.5±1.8		98.4±0.3	564.3±4.8
	(n=62)*								
IIIw	Range	84.0–98.0	70.0–84.0	196.0–252.0	196.0–252.0	182.0–252.0		98.0–112.0	532.0–644.0
	Mean±S.E	84.5±0.3	83.4±0.3	228.0±1.9	227.0±2.4	219.2±2.2		98.6±0.6	589.4±4.4
	(n=50)								
IVa	Range	98.0-112.0	84.0-98.0	336.0-448.0	280.0-378.0	252.0-336.0		112.0-126.0	616.0-756.0
	Mean±S.E	105.5±0.9	85.0±0.5	394.0±3.4	334.0±3.7	299.9±2.8		123.8±0.7	676.6±4.4
	(n=52)								
IVw	Range	84.0–112.0	84.0–98.0	420.0–462.0	322.0–406.0	280.0–336.0		112.0–126.0	672.0–742.0
	Mean±S.E	96.8±0.5	88.0±1.2	436.5±2.1	357.0±5.2	312.5±3.0		123.5±1.0	714.0±3.6
	(n=28)								

n = No. of observations.
* No. of observations for hind tibia and siphunculi = 40.
IIIa, IVa = Third and fourth apterous instar.
IIIw, IVw = Third and fourth alate instar.

this being the most obvious morphological difference between these instars and earlier ones.

The additional antennal segment arises from the division into two parts of antennal segment III of the second instar. These two parts are the same as seen through the cuticle in old second instar aphids. In *S. avenae,* wing pads appear at the third instar; they are minute and do not overlap. In contrast, wing pads are well-developed and overlap one another in the fourth alate instar. The number of setae on the cauda and sub-anal plate of the third and fourth instars showed overlap in their ranges. Third and fourth apterous instars are easily separated from each other by the lengths of the third and fourth antennal segments which do not overlap in the two instars. A highly significant difference ($P < 0.001$) was found in the ratio of the length of the third to the fourth antennal segment. The third antennal segment in the third apterous instar has the same length as the fourth antennal segment but it is distinctly longer in the fourth apterous instar. This difference was found to be a very useful and practical character when large num-

TABLE 3. Range, mean and standard error of the length of hind tibia and siphunculi in each instar of *Sitobion avenae* in μm at 20° C.

		Hind tidia	Siphunculi
I	Range	392.0–504.0	70.0–98.0
	Mean±S.E	426.8±3.5	85.9±0.7
	(n=86)		
II	Range	560.0–700.0	154.0–196.0
	Mean±S.E	626.2±5.7	176.8±1.9
	(n=60)		
IIIa	Range	756.0–952.0	252.0–308.0
	Mean±S.E	852.6±9.7	280.3±3.3
	(n=62)*		
IIIw	Range	756.0–980.0	252.0–308.0
	Mean±S.E	879.7±7.8	283.5±2.6
	(n=50)		
IVa	Range	1064.0–316.0	364.0°476.0
	Mean±S.E	1187.1±10.1	422.7±4.7
	(n=52)		
IVw	Range	1120.–1316.0	392.0–476.0
	Mean±S.E	1227.5±12.7	423.5±4.7
	(n=28)		

n = No. of observations.
* No. of observations for hind tibia and siphunculi = 40.
IIIa, IVa = Third and fourth apterous instar.
IIIw, IVw = Third and fourth alate instar.

bers of aphids had to be sorted out into instars (Lykouressis 1982).

The Key constructed on the basis of the above data enables immature stages of *S. avenae* to be identified to instars with certainty under a binocular dissecting microscope at 20 × magnification. The features in italics in the Key were found the most practically useful for easy and rapid instar identification.

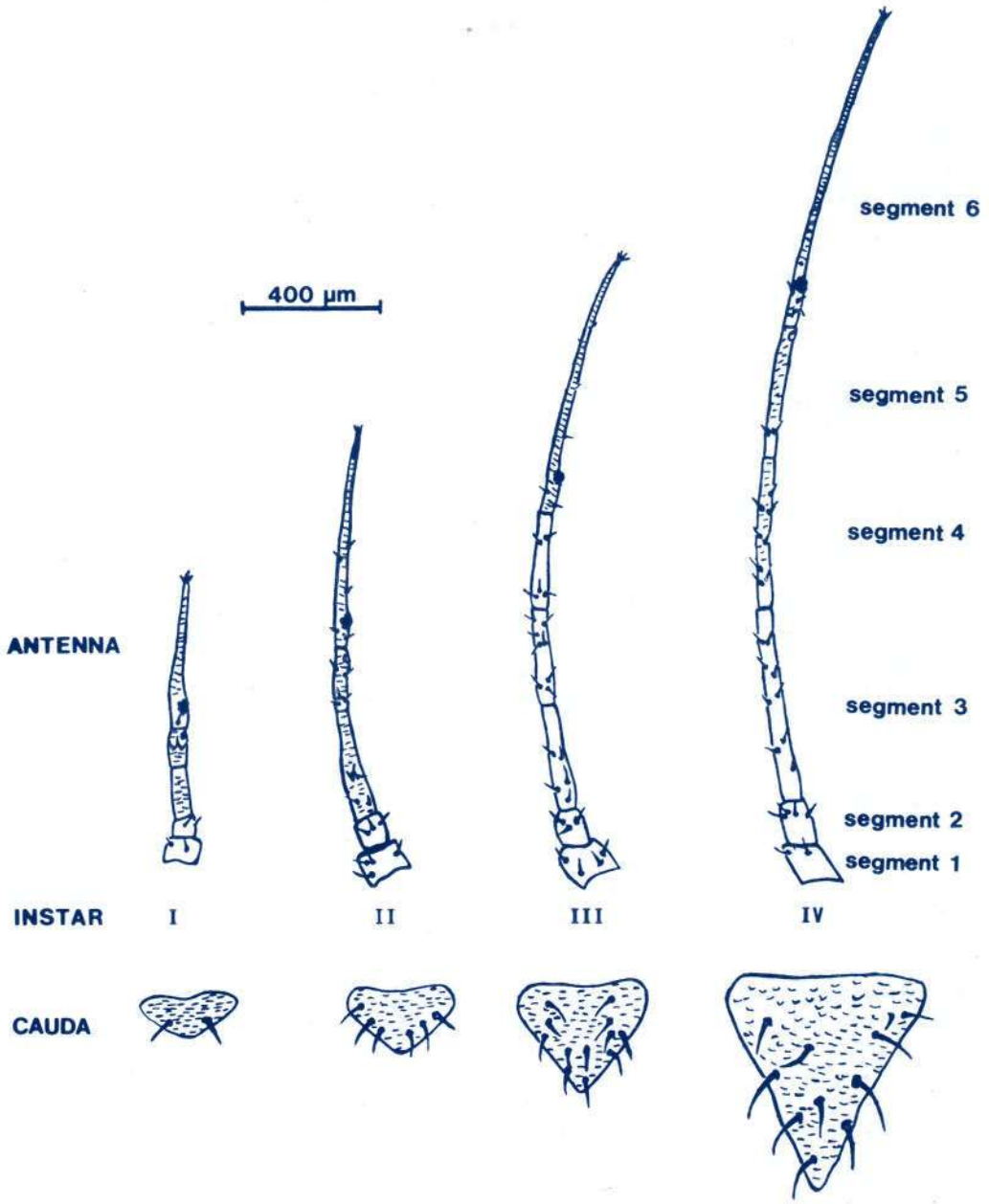

FIG. 1. Structure of antenna and cauda of *Sitobion avenae* (F.).

KEY FOR THE IMMATURE STAGES OF *S. AVENAE*

1. *Antenna of five segments* 2
   Antenna of six segments 3
2. Cauda with only two setae. Sub-anal plate with four setae. Third antennal segment without setae; *its length ranges from 112-140 μm (mean 126.6 μm). Third antennal segment 1.343 ± 0.098 times longer than fourth* .... First instar.
   Cauda with more than five setae. Sub-anal plate with more than seven setae. Third antennal segment with setae, *its length ranges from 196-280 μm (mean 249.5 μm). Third antennal segment 1.648 ± 0.083 times longer than fourth* .....Second instar.
3. Third, fourth and fifth antennal segments all approximately the same length. The length of the third antennal segment ranges from 196-252 μm 4
   Third antennal segment distinctly longer than either the fourth or fifth antennal segment, its length ranges from 336-462 μm 5
4. *Presence of one or two pairs of minute wing pads which do not overlap* .....Third alate instar.
   No wing pads. Third antennal segment ranges from 196-252 μm (mean 214.7 μm) in length. Total length of antennal segments III, IV and V ranges from 532-714 μm (mean 640.4 μm) .....Third apterous instar.
5. *Presence of two pairs of well developed wing pads overlying one another* .....Fourth alate instar.
   Absence of wing pads. Length of antennal segment III ranges from 336-448 μm (mean 394 μm). Total length of antennal segments III, IV and V ranges from 868-1162 μm (mean 1028.1 μm) .....Fourth apterous instar.

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KEY WORDS: Instar, English grain aphid, *Sitobion avenae,* Cauda, Sub-anal plate

Κλειδί για τον Προσδιορισμό των Σταδίων της Αφίδας των Σπόρων Σιτηρών, *Sitobion avenae* (F.) (Hemiptera: Aphididae)

Δ.Π. ΛΥΚΟΥΡΕΣΗΣ

Εργαστήριο Γεωργικής Ζωολογίας και Εντομολογίας
Ανωτάτη Γεωπονική Σχολή Αθηνών

ΠΕΡΙΛΗΨΗ

Ένα κλειδί δίδεται για τον προσδιορισμό των σταδίων της αφίδας *Sitobion avenae* (F.). Το κλειδί βασίστηκε σε χαρακτηριστικά των κεραιών, της ουράς και του οπισθο-εδρικού θυρεού. Τέτοιου είδους κλειδιά είναι απαραίτητα για τη μελέτη της δυναμικής πληθυσμών αφίδων στον αγρό.